# Xuefeng LIU, Ph.D.

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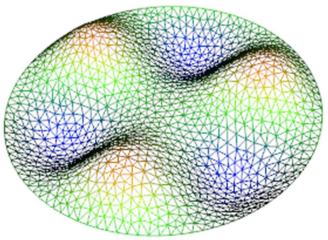
## Professional Expertise

Dr. Liu's research focuses on numerical analysis for scientific computing, especially the finite element method (FEM) in solving partial differential equations. The error estimation plays an important role in validating numerical solutions. In his research, delicate algorithms based on FEM are proposed to give guaranteed quantitative error estimation for approximation solutions. Also, for the well-known problem of lower bounds for eigenvalues, he developed new theories to give verified and sharp bounds for eigenvalues of partial differential operators. Such algorithms and theories are also applied in computer-assisted proof of verifying the solution existence and uniqueness of non-linear partial differential equations.

## Research Fields of Interest

**Eigenvalue estimation for differential operators**

To give lower bounds for eigenvalues of partial differential operators remains very difficult although upper bounds can be easily obtained. With newly developed theorems along with non-conforming finite elements, lower eigenvalues bounds become possible for several differential operators such as Laplace operators, Biharmonic operators. Part of the research results on eigenvalues bounds with online demonstrations is available on this site: http://www.xfliu.org/onlinelab



*Eigenfunction of Laplacian*

**Quantitative a posteriori error estimation of finite element method**

The classical error analysis theories for finite element method mainly focus on the qualitative one, such as the convergence order, the stability. However, in many cases, for example the computer-assisted mathematical proof, the concrete values or bounds of approximation errors are needed. For this purpose, we need to challenge the following problems:

1) concrete values of many error constants, such as the Babuška-Aziz constant;
2) singularities of PDE solutions in case of domain with an re-entrant corner.

The research of finite element methods includes conforming FEMs, non-conforming FEMs, mixed FEMs and hybrid FEMs.

**Verified computation for computer-assisted proof**

"Verified computation" means solving various problems with verified results. The approximation schemes and floating-point number operations bring error to numerical computation results. Due to such error, these results are no more than approximate solutions. The quantitative error estimation and the interval arithmetic provide powerful theories and computation tools to obtain mathematically exact results. Such theories are applied in investigating the existence and uniqueness of solution to non-linear partial differential equations.

**Cloud computing in education and scientific computation**

The cloud computing is a new technology, which has great potential in both education and scientific computation. A Cloud Education System (CES) is set up to provide on-demand and on-line computing, which brings the latest cloud-computing to students and researchers in an easy way. ( http://www.cloud2015.org )

## Education

2009: PhD. in Math. Sci., Graduate School of Mathematical Sciences, Tokyo University, Japan
2006: M.S. in Math. Sci., Graduate School of Mathematical Sciences, Tokyo University, Japan
2003: B.S. in Info. & Comp. Math., University of Science and Technology of China, China

## Professional Societies and Activities

1. Member of The Japan Society for Industrial and Applied Mathematics
2. Member of Society for Industrial and Applied Mathematics (USA)

## Awards

1. SCILAB Toolbox Japan Contest 2012, Best Award in general category, Oct.29, 2012

## Major Publications

### Papers


[1] Xuefeng LIU, A framework of verified eigenvalue bounds for self-adjoint differential operators, Applied Mathematics and Computation, in press, doi:10.1016/j.amc. 2015.03.048

[2] Kazuaki Tanaka, Akitoshi Takayasu, Xuefeng Liu, Shin'ichi Oishi, Verified norm estimation for the inverse of linear elliptic operators using eigenvalue evaluation, Japan Journal of Industrial and Applied Mathematics, 31(3), pp 665-679, 2014

[3] Akitoshi Takayasu, Xuefeng Liu and Shin'ichi Oishi, Remarks on computable a priori error estimates for finite element solutions of elliptic problems", NOLTA, IEICE, Vol.5, No.1, pp. 53-63, 2014.

[4] Xuefeng Liu and Shin'ichi Oishi, Guaranteed high-precision estimation for P 0 interpolation constants on triangular finite elements, Japan Journal of Industrial and Applied Mathematics, 30(3), pp.635-652, 2013.

[5] Xuefeng Liu and Shin'ichi Oishi, Verified eigenvalue evaluation for Laplacian over polygonal domains of arbitrary shape, SIAM J. Numer. Anal., 51(3), pp.1634-1654, 2013.

[6] Akitoshi Takayasu, Xuefeng Liu and Shin'ichi Oishi, Verified computations to semilinear elliptic boundary value problems on arbitrary polygonal domains, NOLTA, IEICE, E96-N(1), pp.34-61, 2013.

[7] Xuefeng Liu and Fumio Kikuchi, Analysis and estimation of error constants for P0 and P1 interpolations over triangular finite elements, J. Math. Sci. Univ. Tokyo, 17, p.27-78, 2010.

[8] Fumio Kikuchi and Xuefeng Liu, Estimation of interpolation error constants for the P0 and P1 triangular finite elements, Computer Methods in Applied Mechanics and Engineering, 196(37-40), pp.3750-3758, 2007.

[9] Fumio Kikuchi and Xuefeng Liu, Determination of the Babuska-Aziz constant for the linear triangular finite element, Japan Journal of Industrial and Applied Mathematics (JJIAM), 23(1), pp.75-82, 2006.

[10] Ghulam Mustafa and Xuefeng Liu, A subdivision scheme for volumetric models. Appl. Math. J. Chinese Univ. Ser. B, 20(2), pp.213-224, 2005.

[11] Ghulam Mustafa and Xuefeng Liu, A New Solid Subdivision Scheme, Journal of University of Science and Technology of China, 35(3), pp.285-300, 2005.

[12] Xuefeng Liu, Blending Pipe Surface by Ringed Surface and Its Continuity(in Chinese), Journal of University of Science and Technology of China, 34(1), pp.20-28, 2004.

[13] Xuefeng Liu, Jin Xu and Ronggang Bai, 3D Rebuilding of Vessel (in Chinese), Journal of Engineering Mathematics, 19, Supp., pp.35-40, 2002.